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The Eye Structure of the Four-eyed Blenny, *Dialommus fuscus* Gilbert.

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(Plates I & II; Text-figures 1-3).

Interest in the peculiar horizontally divided eye of *Anableps* led us to search for the possibility of the existence of other species of fishes that might show a similar or analogous condition. Thus far only a single species has been found which on superficial examination reveals a dark division running across the corneal surface. Specimens of this species, *Dialommus fuscus* Gilbert, were kindly supplied to us by Dr. H. Walton Clark of the California Academy of Sciences, and these form the basis of the present report.

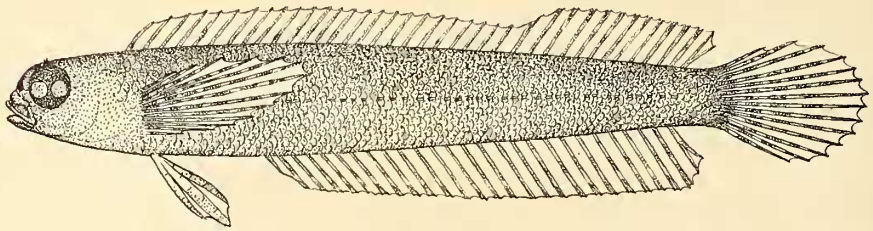
Superficial examination shows what appears to be a dark and nearly *vertical* band reaching across the eye. Closer examination shows that this area of pigment actually is so arranged as to give the impression of an opaque cover through which there are *two* circular openings through which light may pass. This is indicated in Pl. I, Figs. 1-5, and diagrammatically in Text-figs. 1-3. A description of the condition, based chiefly on serial sections, follows.

The eyes are lateral, externally circular and heavily pigmented. The diameter of the cornea is 3 mm. in a specimen of 72 mm. standard length. In each of the lower quadrants a clear corneal area of 1 mm. in diameter is present reaching laterally to the limbus but separated from each other by the aforementioned pigment band. No secondary limbus for the two cornealae are differentiated. The entire cornea is weakly convex in its outer curvature and without local change in the smaller corneal areas or in the pigmented areas; nor are there differences in the corneal thickness in the various areas. The remaining structures of the eye are of normal piscine character.

The corneal pigmentation is of melanophore cells derived from the dermal melanophores by extension into the cornea as a single-layered sheet of cells in the tissue plane between the true and false corneal epithelium. There is a secondary spread into the superficial epithelium especially in the intervening area of the cornealae, in which area pigment cells interweave between the epithelial cells themselves. No melanophores are found in the stroma of the true cornea. The transparent cornealae are sharply demarcated by the pigment cells without the presence of a transition zone comparable to a limbal area.

The anterior chamber is of usual depth throughout; the iris is silver gray in color and of normal structure both as to position and its somewhat horizontally oval pupillary opening. No adhesion between iris and cornea exists as is found in *Anableps anableps,* which aside from the rotation of the ocular "septum" has a quite different structural pattern. Furthermore, in *Dialommus* there is only one pupillary opening present in the iris instead of two as in *Anableps* (see Text-figs. 2 & 3). The crystalline lens is spherical and shows no curvature alterations that might be expected in so odd a corneal optical system—and are, in fact, realized in that of *Anableps.*

No necessity exists to describe the retina, choroid, optic nerve or sclera in detail in this place as these layers are comparable to fish eyes in general.



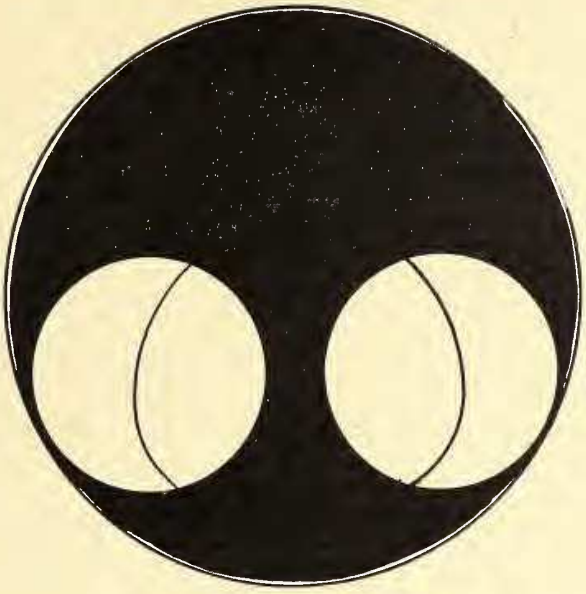
Text-figure 1.

Dialommus fuscus Gilbert, 51 mm. in standard length. Drawing by Ralph Graeter.

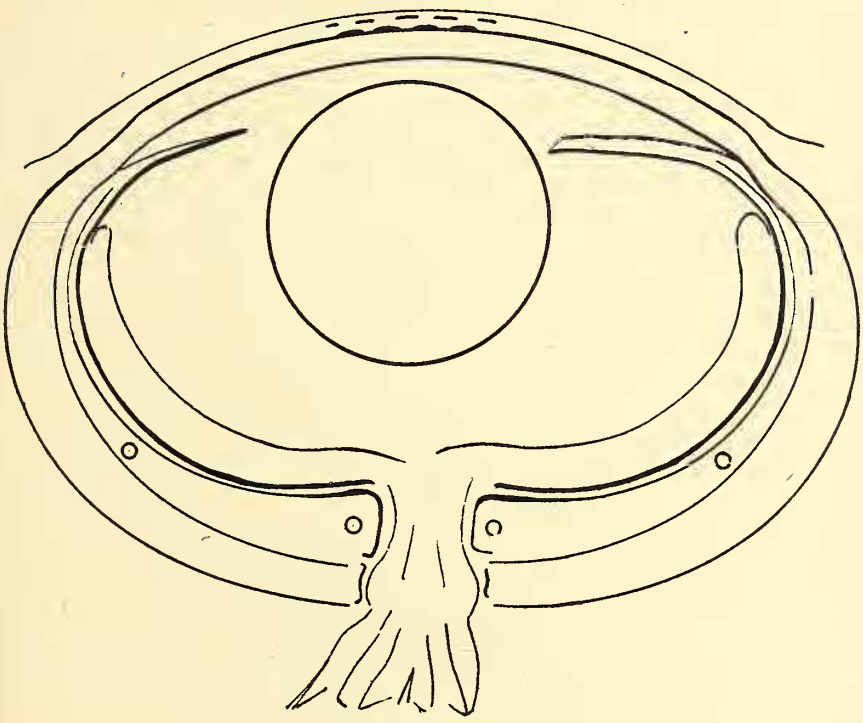
Gilbert (1891) in his diagnosis of the monotypic genus *Dialommus* wrote: "Eyes as in Anableps, the cornea divided by an oblique pigmented band into an anterior lower and a posterior upper half." Unfortunately he gives no figure, but an examination of our illustrations shows that the division, in our material as already noted, is nearly vertical with a slightly backward slant from the top downward. The material on which these notes are based was collected at Academy Bay, Indefatigable Island, Galápagos, on May 9, 1932, by the Templeton Crocker Expedition for the California Academy of Sciences.

Since it is known that *Anableps* swims at the surface with the upper part of its eyes thrust into the air and that the peculiar distortion of the crystalline lens and corneal curvature provides for suitable focus in air and water, respectively, through the upper and lower pupil, it is generally assumed that this condition gives the fish a visual advantage (e.g., Clarke & Mortimer, 1839; Klingelhöffer, 1910). See Plate I, Fig. 6, and Plate II. Observations on both *Anableps anableps* Linnaeus and *Anableps dowei* Gill in aquaria have not served to clarify this contention, although the fishes certainly hold themselves for the major portion of the time in such a position that the surface meniscus rests between the two pupillary openings. While they are clearly alert to conditions above the surface, it would be hard, on a basis of our observations, to demonstrate that they are any more so than many other surface fish, for example, their relatives the Poeciliidae. Like many of the latter, they are omnivorous with a decided predilection for algae-eating, for which their mouths are well suited, although it is not clear what advantage such a four-eyed condition would confer.

Although we have not been able to examine living specimens of *Dialommus,* we have the valuable description given by Dr. Clark (1936) of their field behavior under the name of *Crockeridius odysseus.* Like *Anableps* they live near the water's surface but unlike the latter, instead of swimming in quiet waters for most part, are found on more or less exposed rocky shores where there is a surf. Here they apparently spend as much time out of as in the water. Of this behavior Clark wrote: "The



Text-figure 2.
Diagrammatic aspect of lateral view of eye of *Dialommus*.



Text-figure 3.
Reconstructed diagrammatic horizontal section of eye showing typically piscine appearance of eye of *Dialommus* except for the vertical band of corneal pigment.

first example seen was noticed on the top of a rock along the shore of Wreck Bay, Chatham Island, April 18. It looked very much like a curled-up salamander, with black, smooth, glistening skin and prominent beady, watchful eyes. Upon approaching with a dipnet, it sprang into the water. From time to time about a dozen more were seen coiled up on rocks, and it was then ascertained that they were fish. They were seen from time to time making quick jumps from and over rocks into deeper water. From their alertness and activity and their unexpected position they were apparently the most elusive of fishes and probably absent from collections. Beebe had apparently caught glimpses of them, for he remarks (Galapagos p. 112): 'Blennies climbed out and flicked here and there upon tide-soaked rocks.' " Clark further states: "They seem to be neither ocean nor tide-pool fishes but rather pot-hole inhabitants, living, along with the suck-fishes (Gobiesocidae), in deep depressions back some distance from all but the highest tides. Unlike the suck-fishes they have no means of attaching themselves firmly to rocks against the dash of surf. They showed great alacrity in climbing out of the steep sided pools and it was only by administering poison and keeping them down in the pools that they could be collected in such situations. They were indeed able to ascend the smooth vertical side of the enameled collecting can."

Since the eye partition is nearly vertical, it is tempting to imagine that these fish spend considerable time clinging to the vertical sides of their pot-holes with only the forepart of the head thrust out of water so that the water's edge passes between their paired cornealae in a manner analogous to that to be seen in *Anableps*. Unfortunately for such an idea, the illustrations here shown give no evidence of structural peculiarities that would suggest an optical advantage for such behavior. Stated rather flatly, the eye seems to be nothing more than that of a typical fish, suitable for underwater vision, with a covering so arranged that vision is possible only through a fore and aft opening. If this confers any optical advantage, it is certainly not evident from present data.

This item cannot be dismissed so simply, however. Since fishes make visual adjustments by moving the lens back and forth, instead of deforming it, there is a possibility of some lateral movement. This is especially noteworthy, as in the normal fish eye there is a slight rearward movement of the lens as it is retracted, due to the structural features of the mechanism involved. Thus it is conceivable that these fishes could so operate their lens movements as to allow the anterior portion to be in focus for aerial vision while the posterior portion was focussed for vision in water. Obviously such minor adjustments if existent could not be detected in the sectioned eye.

Abandoning any attempt to impute any particular advantage to this condition in the sense that it is alleged for *Anableps*, another feature of fish eyes may be considered. Umbulacra of various sizes and shapes are not uncommon in fishes. These are not infrequently associated with environments of very bright light and presumably act as visors. If we may accept the view of Breder (1932) who thought that various belonids which live over very bright and reflecting sand in shallow water may derive some optical advantage from having umbulacra and a horizontally closing pupil, certain hypotheses may be considered. His idea was that the umbulacrum protected permanently from the usual glare from above and the horizontally contracting pupil from the secondary and more variable glare from below. On such a basis the condition in *Dialommus* may be thought of as associated with a life spent largely in an even greater glare and in which extensions of the dorsal and ventral umbulacrum-like protection fused somewhat below the center of the orbit, resulting simply in an accidental condition of two visual openings.

This suggestion, of course, may be countered by citing all manner of

optical peculiarities in one species or another involving variants of off-circular openings which cannot be associated with any environmental features. It might be held, on the other hand, that these structures are sufficiently unimportant to permit their taking nearly any form so long as it is not positively detrimental. Heavy pigmentation and its extension into areas not usually pigmented, in a general way, are frequently associated with environments exposed to large amounts of illumination. In this connection it may be noted that the general dermal pigmentation in our material is extremely heavy.

References.

Breder, C. M., Jr.

1932. On the Habits and Development of Certain Atlantic Synentognathi. *Papers Tortugas Lab.* 28 (1): 1-35. Carnegie Instit. Wash. Publ. 435.

Clark, H. W.

1936. The Templeton Crocker Expedition of the California Academy of Sciences, 1932. No. 29. New and Noteworthy Fishes. *Proc. Cal. Acad. Sci.*, Ser. 4, 21 (29): 383-396.

Clarke, W. H. & Mortimer, J.

1839. On a fish with four eyes. *Rept. Brit. Assoc. Adv. Sci.* 8 meet. (1839): 110.

Gilbert, C. H.

1891. A supplementary list of fishes collected at the Galapagos Islands and Panama, with descriptions of one new genus and three new species. *Proc. U. S. Nat. Mus.* 13 (1890): 449-455.

Klingelhöffer, V.

1910. *Anableps tetrophthalmus. Wochenschrift für Aquarien—und Terrarienkunde.* Jahrg. 7 (5): 62.

EXPLANATION OF THE PLATES.

Plate I.

Sections of the eye of *Dialommus* and *Anableps.*

Fig. 1. *Dialommus.* Preserved head. Shrinkage of the eye somewhat distorts the appearance, but the only non-pigmented areas show cavetation.
Fig. 2. *Dialommus.* Vertical section, anterior to the central pigmented band.
Fig. 3. *Dialommus.* Horizontal section showing median pigment band.
Fig. 4. *Dialommus.* Horizontal section showing the pupil and the two cornealae.
Fig. 5. *Dialommus.* Higher magnification of the median central barrier.
Fig. 6. *Anableps anableps.* Vertical median section showing the two pupillary openings.

Plate II.

Fig. 7. Eye of a living *Anableps anableps* (Linnaeus). Photographed under water in an aquarium by S. C. Dunton.